Flora W. Patterson

E. W. P.

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
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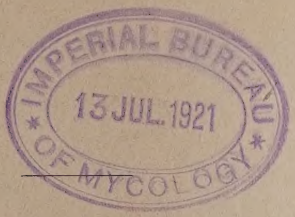

THE OLIVE KNOT

BY
FREDERIC T. BIOLETTI
Instructor in Practical Wine-Making and Bacteriology

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THE OLIVE KNOT

By Frederic T. Bioletti,

The Olive Knot is a serious disease of the olive tree, from which, until lately, California seems to have been exempt. Its recent discovery in Merced County, however, makes it necessary that those interested in olive growing should be made fully acquainted with all that is known of a practical nature regarding the disease, in order that its spread shall be restricted as much as possible. It is quite possible, indeed probable, that the disease exists in a mild form in other districts, where it is prevented, by the local conditions, from increasing to a noticeable extent or doing any appreciable damage. There is danger, however, if such districts exist, that they will serve as centers of infection, from which the disease will spread to other districts, where a different set of conditions will allow it to assume a more virulent and destructive form. As no satisfactory curative measures are known for a tree once badly attacked, it is important that strict quarantine measures should be taken. This is especially true in the case of infected nurseries, or of olive groves from which buds or cuttings are taken for propagation.

Name of the Disease.—The disease which is designated here as *Olive Knot*, is known in Europe under many names, among the commonest of which are *Rogna*, in Italy, and *Gale*, in France, both words about equivalent to the English "mange". In scientific publications it is generally spoken of as "*Tuberculosis of the Olive*". This name, though very descriptive, is undesirable for the reason that, to some people, it carries with it the idea of a connection between this disease of the olive and the tuberculosis of animals and man. Both diseases are caused by bacteria, but so is the production of vinegar; there is no other connection between the two, and no possibility of one producing the other. To avoid giving a wrong impression, then, it seems best to adopt the equally appropriate and descriptive name of Olive Knot.

Distribution.—The Olive Knot occurs in all parts of Italy, in Egypt, in Southern France, and probably in all parts of the olive-growing region bordering on the Mediterranean. As a rule, the disease is worst in the most southerly districts, and especially in those where the orchards are most thoroughly cultivated. The distribution

is, to a great extent, sporadic, both as regards the whole Mediterranean region, and as to particular localities. Some of the most seriously affected districts are widely separated; and in the same locality badly diseased orchards lie side by side with orchards that are almost free. Occasionally only a few trees in an orchard are affected, and the disease remains for a long time confined to them without showing any tendency to spread. That it does spread, however, from a center to surrounding trees and localities, like other infectious diseases, is undoubtedly true in most cases.

HISTORICAL.—Although this disease is said to have been known to the Romans, and to have been described by both Theophrastus and Pliny, it was not until about the middle of this century that it attracted any considerable attention. So long as only the hardier varieties were grown, and intensive cultivation of the olive had not been adopted, the disease was limited in range and comparatively harmless. As soon, however, as the finer and more delicate varieties of olives were planted, and olive orchards were subjected to modern methods of cultivation, irrigation and manuring, the conditions most favorable to the disease were established, and the damage occasioned by the "Tuberculosis of the Olive" became serious.

The strong resemblance of the olive knots to the galls produced by insects on many plants led most of the earlier observers to believe that they, too, were caused by insects. The mistake was the more easily made as the galls are often found pierced by insects, which have used them for food or shelter.

In 1768, G. Targioni-Tozzetti, in describing the olive trees of Monti Pisani, mentions the Olive Knot and states that, appearing first at Monte Morelli, it had spread over a large part of Tuscany. He ascribed the disease to the attacks of insects. In 1787, A. M. Fineschi describes an invasion of this disease in the olive orchards surrounding Siena, consequent on the cutting-back and manuring of the trees. In 1789, G. M. Giovene, and in 1790, C. Moschettini, published in Naples the first complete and accurate accounts of the disease. They considered the cause to be a plethoric condition of the tree. The infectious nature of the disease has long been known in some parts of Italy, to the peasants who prune the trees. In 1817, C. Pollini states that the pruners believed that it was possible to give the disease to healthy trees by pruning them with implements used on affected trees. A. Costa (1877), in Southern Italy, was the first to show conclusively that the knots are not due to insect attack, by pointing out that there are no cavities nor insects in most of them, and that the few insects that are found in them are of various species.

In 1886, Arcangeli and Savastano discovered the presence of a species of bacterium in the incipient olive knots. The former named it *Bacterium oleae*, but did not believe it to be the cause of the disease. Savastano was the first, in 1887, to prove, by means of inoculations, that the bacterium is the real inciting cause. He made a very thorough and complete study of the knots and of the bacterium. The following illustration is a reproduction of a drawing by Cavara, showing the microscopic appearance of a section of one of the knots, and also of the bacterium, which is now called *Bacillus oleae*.

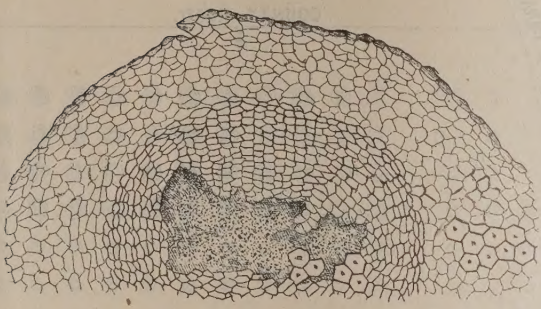

FIG. 1.

Section through a young knot, showing "callus-like" hypertrophied tissue and the central hollow containing the colony of bacteria. Below it is shown the microscopic appearance of the *Bacillus oleae*.

OCCURRENCE OF THE DISEASE IN CALIFORNIA:—Olive Knot was first noticed in California in an orchard near the town of Merced. Mr. A. R. Gurr first observed it in 1893 on a single tree. Since then it has been gradually spreading, until now it has destroyed several trees and has spread over a large part of the orchard.

A visit was made to Mr. Gurr's place in February, 1898, with the object of investigating the disease on the spot.

The orchard is on a rich sandy soil near an irrigating canal and is thoroughly sub-irrigated. The water level is said to be, on the average, about five feet from the surface. The trees grow very vigorously and bear well. They were not pruned much until attacked by the disease, when pretty severe cutting-back was resorted to with the idea of removing the diseased parts. The affected trees immediately surround those first attacked, while the part of the orchard farthest removed from the point of infection is yet free from the disease. The following plan of the affected orchard *(fig. 2)*, drawn from data furnished by Mr. Gurr, shows graphically how the disease has spread from the tree first attacked (A) to the surrounding trees.

Some large trees were found to be literally covered with knots. They occurred on the main trunk, branches and twigs, and were particularly abundant wherever the tree had been cut or otherwise injured. These trees showed the effect of the disease in limited growth, scanty foliage, and occasional dead branches, and were evidently on the point of succumbing. Other large trees, which had not been affected long, showed immense numbers of knots on the small twigs, but very few on the trunk and branches. These trees looked as vigorous and healthy as the unaffected trees and had borne a large crop. Finally, on the edges of the affected area the trees showed only a few knots, which in nearly all cases were on the small twigs.

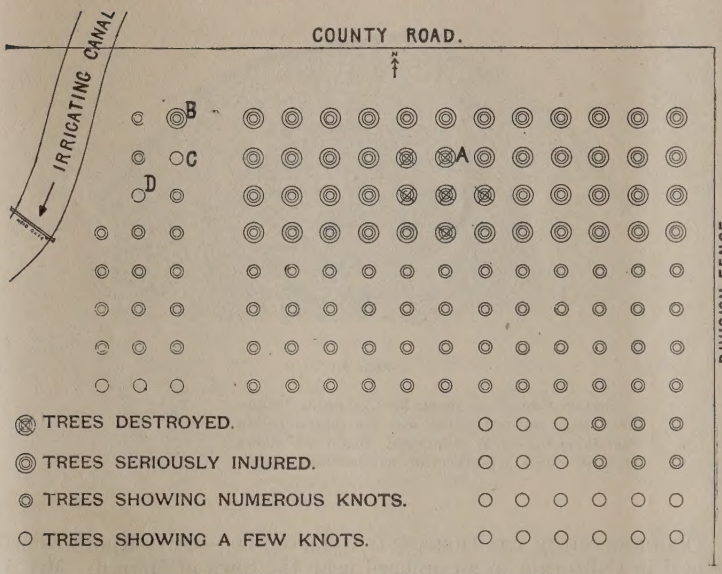

FIG. 2.—PLAN OF THE AFFECTED ORCHARD.

A. The first tree on which the knots were noticed.
B. Tree showing an immense number of knots.
C. Mission Olive almost free from knots.
D. Redding Picholine almost free from knots.

There was little evidence on which to base a judgment as to the various degrees of susceptibility of the various varieties grown here. The Columbella seemed to be particularly susceptible, most of the dead trees being of that variety, but this may be due simply to the fact that they happened to be in the area first attacked. The Mission and Redding Picholine seemed to be comparatively resistant, as far as could be judged from a single tree of each variety growing next to badly diseased trees on the edge of the affected area (*see C, D, fig. 2*). In general, the old trees were attacked principally on the younger parts. Correlated with this is the fact that young trees were evidently more susceptible than old, and suffered more injury from the attack. Young trees planted to replace trees destroyed by the disease were in all cases literally covered with tubercles (*see plate 3*) and in some cases killed. The tree represented in the figure had over ninety knots.

Wherever a jagged wound, such as that made by tearing off a branch, or by a blow from the plow, was seen, the tubercles were very numerous. The edge of such a wound is evidently an excellent place for infection (*see plate 5*). The smooth wounds made in pruning were much less severely or generally infected.

The roots seemed little affected. A small tree, which was a mass of tubercles above ground, showed only one about the size of a pea on the roots (*see plate 3*).

Occasionally, small tubercles, varying from the size of a pinhead to that of a pea, occurred on the *leaves*, generally on the under side.

2 1 3

PLATE 3.

1.—Young tree planted to replace one destroyed by knot. Photograph taken twelve months after planting.

2.—Large knots on branch of old tree.

3.—Small knots on weakened branch.

The occurrence of affected leaves was very irregular, most trees showing none. When they did occur they were generally confined to one or two small branches, and even then were not numerous. It was only rarely that nearly all the leaves on a small branch exhibited tubercles. The number of knots on the leaves seemed to bear no relation to the severity of the attack on the rest of the tree. Some of the most badly affected trees showed no excrescences on the leaves.

What fruit remained on the trees was too badly frost-bitten for judging whether or not it had been invaded by the bacteria. Mr. Gurr said, however, that the olives on diseased trees seemed affected, and that an attempt to pickle them failed, as they decayed before they were ready for the brine.

NATURE OF THE DISEASE.—Savastano* describes the *Tuberculosis of the Olive* as follows: "The tubercles which characterize this disease are generally formed on branches of from one to fifteen years of age, where the bark is still smooth and not cracked. They are generally isolated, but sometimes take the miliary form. They are rare on the roots, and still more so on the leaves and fruit. So far I have not found them on the flowers, but believe they may occur there.

"The formation of a tubercle takes place in the following manner: Generally, quite close to the cambium layer, and most frequently in the bast, a colony of bacteria commences to form. To the unaided eye it appears as a small transparent spot. With a magnification of 1000 diameters this is seen to be a colony of bacteria. At the same time a hypertrophy of more or less degenerated elements commences to form around this colony. The colony increases in size and becomes dark-colored. The hypertrophy increases, causing the tubercle to enlarge and finally burst through the cortex and split. A tubercle, thus formed, continues to grow each year more or less until it attains a diameter of from one to two centimeters. The tubercles commence to form in the spring; during the heat of summer the hypertrophy is arrested, but the colony of bacteria continues to increase. Later, during the autumn vegetative growth, the hypertrophy recommences. In the fruit there is no true hypertrophy."

Prillieux explains the formation of the knots under the influence of bacteria as the natural effort of growing parts of the plant to heal injuries. *Callus* or healing tissue forms on the first attack of the bacteria in the same manner as when the plant receives a mechanical wound. This tissue being soft is immediately attacked by the increasing colony of bacteria, and fresh callus is formed until the twig attacked becomes too weak to form more, when the further enlargement of the knot comes to an end.

Savastano investigated the influence, on this disease, of cuts, bruises, pruning and other mechanical injuries to the plants, and came to the following conclusions:

"(1) Wounds do not cause tubercles except on plants which are already predisposed to the disease. (2) Even in these plants a wound does not always cause the formation of tubercles. (3) Heavy pruning causes the formation of new tubercles, and an increase in size of the

* Comptes Rendus de l'Academie des Sciences; CIII., 1144.

old on affected trees. (4) The formation of tubercles is in direct ratio to the vigor of the plant."

Savastano's researches show that some varieties of olive are more susceptible to the disease than others, but that all varieties may contract the disease when the conditions are those which most favor its growth. The most susceptible varieties are unfortunately the heaviest bearers, and those with the finest fruit. The conditions which predispose the tree to the disease are: rich soil; excessive irrigation or rain; heavy manuring; thorough cultivation; severe pruning. Anything, in fact, which tends to produce vigorous vegetation or high sap pressure tends to make the tree more susceptible.

The manner in which the tree becomes infected with the disease is not known positively in all cases. Anything which wounds the bark, such as cuts, bruises, hail, frost, pruning, grafting, budding, etc., is often followed by a growth of tubercles, as it allows the entrance of bacteria. The disease occurs sometimes, however, in places where there has apparently been no mechanical injury to the tissues of the tree. It is quite possible that biting and sucking insects may, in piercing the bark, inoculate the tree with the disease. According to Vuillemin, a certain fungus is always found associated with the Olive Knot. This fungus, he claims, penetrates the tissues of the tree and opens the way for infection by the bacteria.

That the disease is infectious, and is caused by bacteria, there seems to be no doubt. Savastano states: (1) That a colony of bacteria is to be found in the earliest stage of the formation of all tubercles. (2) That he found the same species of bacterium in all the hundreds of tubercles he examined. (3) That the spread of the disease from a first infected center to surrounding districts has often been observed.

Later, Savastano made pure cultures of the bacterium, and inoculated many plants both with this and other kinds. The results obtained were that inoculation with the tubercle bacterium nearly always produced tubercles on the olive, but never on other plants, while inoculations of many other kinds of bacteria never produced tubercles on the olive, or only so rarely as to be accounted for by accidental infection.

Symptoms of the Disease.—A complete account of the effects of the disease on the trees cannot be given at present, as only one visit has been made to the affected orchard. At other seasons of the year other symptoms may be shown. The disease has no apparent effect on the general health of the tree until it becomes literally a mass of knots. It is but rarely that a branch or twig is killed while the rest of the tree remains healthy, and it is not until the last stage is reached that there is any diminution of vigor or fertility in the affected tree. The symptoms, therefore, may be said to be confined to the various kinds of excrescences which appear on the different parts of the tree, and a description of these will suffice to characterize the disease.

The knots on the *leaves* are always small, especially when they are numerous. They vary from the size of a pin-head to three-sixteenths of an inch in diameter. They occur almost always upon the lower surface only, but show through on the upper surface as brown spots. This shows that the leaf tissue is killed quite through the leaf. On

the *leaf stalks* the knots are generally larger, say one-fourth to three-sixteenths of an inch (*see plate 4*).

On the *small twigs* of vigorous trees the knots often measure one inch across, and become much contorted and split up by drying-out and the pressure caused by the continuous growth of new tissue within and at the base (*see plate 4*). However large a knot becomes it seldom or never involves the whole circumference of a twig. On the side opposite the knot the bark seems healthy. This accounts for the fact that a tree remains green and fresh-looking for so long a time after being severely attacked. Occasionally, especially on young and badly affected trees, several points of infection will coalesce. In this case the bark and growing layer of the twig may be killed all around. Still more rarely the infection seems general on a certain part of the twig, and for an inch or more there will be a kind of breaking-out, owing to a general hypertrophy of the tissues, not arising from any definite points of infection, and not producing definite knots. This is shown somewhat imperfectly just at and below the point of branching by the young tree in the middle of plate 3. The last two cases account for the occasional dead twigs and small branches which occur. In some cases where there is a large number of points of infection, or when the tree is less vigorous, the knots remain small, not exceeding one half inch in diameter. They are also more regular, more nearly spherical, and do not develop so many cracks nor such an uneven surface (*see right side of plate 3*).

On *trunks and branches* the knots finally attain a large size, often becoming as much as two inches in diameter. This seems to be a larger size than they attain in Europe, judging from descriptions. They are flatter, that is, more spreading and less spherical, than on the twigs. Occasionally several or many points of infection occur near together, and the resulting tubercles run together, thus forming a large mass of cracked, diseased tissue several inches across. This is very commonly the case in the infection of ragged wounds, where the points of infection are so numerous that no definite knots are formed (*see plate 5*). The knots occur very often on the old wood near the bases of small twigs coming from adventitious buds. They occur, however, in all situations, and infection appears possible anywhere.

Some of the trees on Mr. Gurr's place which showed a very large amount of olive knot were very heavily loaded with fruit. Several of the older writers make the observation that trees attacked by this disease bear more than they did before. The reason of this is that plants with too much vegetative vigor do not bear well, and that the first attack of the disease by slightly diminishing this vigor makes the trees more fruitful. As the disease progresses, however, the diminution of vigor continues until the plant is unable to produce either fruit or foliage.

There are several kinds of knots, or swellings, common on olive trees, which might carelessly be confused with the real olive knot. First of all there is the common callus or healing tissue of wounds which forms around cuts, grafts, and inserted buds. This forms in a rather thin layer around the edge of the wound, is of different shape, and never reaches the size of the true olive knot. The large swellings,

"uovoli," commonly found on the trunk of the olive tree, especially near the ground, are also of a very different nature. They are perfectly normal and do not indicate a diseased condition. They are indeed used in Europe for the propagation of the olive. They seem, however, to be particularly favorable places for infection and for the growth of the true knot *(see plate 5, right side)*. Finally, old olive trees often develop tumors on the main roots, trunk, and larger branches, the cause of which is not well known. They are flatter, less cracked, and generally grow to a larger size than the tubercles of the Olive Knot. They do not seem to be infectious, nor to do much harm to the tree.

Experiments in the Laboratory.—Most of the knots at this season of the year (February) are old, dry and cracked, and probably do not contain living bacteria. A few knots were found, however, which were still succulent and unbroken. From the interior of these, inoculations were made into the usual bacteriological culture media. Of seventeen inoculations made, eleven showed no growth. One showed growth of one kind of bacterium and a mold. Five showed growth of another kind of bacterium. The last was morphologically the same as Arcangeli's bacterium, as far as indicated by the limited investigations so far made. No bacteria could be found by simple microscopical examination. This was to be expected, as at this season of the year they are probably much reduced in numbers, and in a dormant condition.

Conclusions:—The Olive Knot disease is at present limited to a small range in California, but, as it promises to be very harmful in some localities, special precautions should be taken to prevent its spread.

The one necessary condition for the existence of the disease is the presence of the specific germ, the special bacterium which causes it. If this can be kept away, no other condition will bring about the disease.

Even if the disease germ be present, the trees will not be attacked, or attacked only slightly, if the conditions favoring the growth of the germ do not exist also.

The conditions favorable to the growth of the bacteria and to the production of knots are: (1) Delicacy of the tissues, owing to youth or variety. (2) High sap pressure, due to heavy pruning, irrigation, manuring. (3) Wounds, caused by pruning, grafting, budding, gathering the fruit with rakes, and by injuries due to insects, fungi, wind, the plow, etc. (4) Hot weather. Under the conditions most favorable to the growth and spread of the disease, it may be contracted by any variety. Some varieties, however, are much more susceptible than others. Which varieties these are cannot be exactly stated as yet, at least for California. In general, however, those which are most "highly bred," that is, which are farthest removed from the hardy wild type, are most liable to contract the disease, and are most vitally injured by it. These, unfortunately, are precisely the varieties which are most valuable for the quantity and quality of their crops.

No buds nor cuttings should be taken from infected orchards. All pruning-shears, saws, gathering boxes, etc., used on affected trees

should be thoroughly disinfected before being used anywhere else. This can be done by boiling in water, or by steeping in a solution of one part of corrosive sublimate to five hundred of water, for half an hour or longer.

Where there is danger of infection, all considerable wounds should be painted with an antiseptic and protective paint.

When a tree is first affected all diseased parts should be carefully cut away and the parts burned on the spot.

What pruning is necessary should be done gradually; that is, a little each year. This is not so liable to produce a tendency to contract the disease as a heavy pruning every few years.

Where possible, the presence of too much moisture in the soil should be avoided.

Olives from diseased trees are perfectly wholesome, and probably as good for oil as from healthy trees, unless the vitality of the tree is seriously affected. If the fruit itself is attacked, it is probably useless for pickling.

LIST OF THE MOST IMPORTANT WRITINGS ON THE OLIVE KNOT.

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ARCANGELI:, G.: *Sopra la malattia dell' Olivo detta volgarmente Rogna.* Pisa, 1886.

SAVASTANO, L.: *Tubercolosi, Iperplasie e Tumori dell' Olivo.* Naples, 1887.

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SAVASTANO, L.: *Il Bacillo della Tubercolosi dell' Olivo.* Rome, 1889.

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